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# On a model of Love dynamics: A Neutrosophic analysis

## Abstract

This study is an application of neutrosophy to the dynamics of love, the most interesting social phenomena. The love dynamics were studied earlier by Strogatz (Strogatz, 1994), Radzicki (Radzicki, 1993), Rapport (Rapport, 1960), etc. Although Strogatz's model (Strogatz, 1994) was originally intended only to motivate students, it makes several interesting and plausible predictions, and suggests extensions that produce even wider range of behavior. This paper has been written in the Strogatz's spirit, and it has extended Romeo & Juliet model (Sprott, 2004) to the neutrosophic domain. A love impact factor (LIF) has been proposed, and analyzed using neutrosophic logic.

## Keywords

Neutrosophy, neutrosophic logic, love, romance, human behavior, partner selection, differential equation, love dynamics.

## 1. Introduction

In present days, the human behavior has become an interesting issue to study. Researchers (concerning to dynamics) were looking for some new techniques to study it accurately. Apparently, studying it isn't a difficult task, and obviously it can be easily performed by the psychologists. Though, studying it accurately or near to accuracy, that is a difficult task. It may be achieved by mathematical analysis; but since there always appear indeterminacies, a more detailed analysis is required, and that is the main goal of this paper. In order to do this, we need to define human behavior in terms of equations (with indeterminacy) and we need to form a refined model, based on different feelings, taking into account different conditions. This paper deals with the refinement of love dynamics, a subject that falls in the field of social psychology, where interpersonal relationship are a topic of major concern. The feelings of love transpose in different forms; but here we opt to consider it as partner's love. One may say that romantic relationships are somehow a simpler case, since they involve only two individuals. The analysis has been performed following the modeling approach, with the induction of neutrosophic logic. An obvious difficulty in any model of love is defining what is meant by love and quantifying it in some meaning including intimacy, passion, and commitment (Strogatz, 1988); each type consists of complex mixtures of feelings. In addition to love for another person, there is love for oneself, love of life, love of humanity, and so forth. Furthermore, according to neutrosophy (Smarandache, 1998), the opposite

of love may not be hate, since those two feelings can coexists, and one love some things about one's partner and hate others at the same time. Actually, the feelings in an individual can fluctuate depending on life, position, humanity or partner (Sprott, 2001). These feelings vary from person to person and from time to time. Even if everyone have the same in his/her hearts, the ratio or percentage differs. The feeling in human being varies according to different conditions. For this, different conditions and assumptions have to be applied and therefore we need to move towards an interpretative world or to think for a model that can give the complete dynamics of human feelings. It is obviously unrealistic to suppose that one's love is only influenced by only his/her own feelings and of the other related person, independent of external influences. The parameters that characterize the interactions are unchanged by excluding the possibility of learning (Scharfe & Bartholonew, 1994). However, the major goal in this research is to apply neutrosophic logic in the love model with the form of coupled ordinary differential equations.

This paper has been organized as follows: In section 2, we recall definition of neutrosophy and neutrosophic logic and preliminaries of neutrosophy. Section 3 is devoted to represent neutrosophic love model. Section 4 states open problems. Section 5 presents conclusion.

## 2. Neutrosophy & Neutrosophic logic

According to Prof. Florentin Smarandache (Smarandache, 1998), "*Neutrosophy is a branch of philosophy that studies the origin, nature and scope of neutralities as well as their interaction with different ideational spectra*". Prof. Florentin Smarandache is regarded as the father of neutrosophy, and Prof. Cheng-Gui Huang (Huang, n.d.) claims that neutrosophy is a deep thought on human culture, giving advantage to break mechanical understanding. Neutrosophic theory has been applied in many fields in order to solve problems related to indeterminacy. Neutrosophy is a generalization of Hegel's dialectics. It considers every entity < A > together with its opposite or negation < anti A > idea, refered to together as < non A >.

**Definition** (Smarandache, 1998)

A logic in which each proposition is estimated to have the percentage of truth in a subset T, the percentage of indeterminacy in a subset I, and the percentage of falsity in a subset F, where T, I, F are defined above, is called neutrosophic logic.

Actually, neutrosophic logic is a formal description frame trying to measure the truth, indeterminacy and falsehood. For detailed study of neutrosophic logic, researchers may consult the first book on neutrosophy authored by Florentin Smarandache (Smarandache, 1998). Neutrosophic logic was invented by F. Smarandache in 1995, which is an extension of fuzzy logic, intuitionistic fuzzy logic, paraconsistent logic. It deals with indeterminacy. In neutrosophic logic, every logical variable 'x' is described by an ordered triple x = (t, i, f), where

t → degree of truth,
i → level of indeterminacy,
f → degree of false.

To maintain consistency with classical and fuzzy logic and with probability, there is a special case where t + i+ f = 1. But to refer to intuitionistic logic, which means incomplete information on a variable, proposition or event, one has t +i+ f <1. Analogically, referring to paraconsistent logic,

which means contradictory sources of information about some logical variable, proposition or event, we have t + i +f > 1. Florentin Smarandache (Smarandache,1998) defined neutrosophic components. Assume that T, I, F be standard or non-standard real subset of $]^{-}0,1^{+}[$. Florentin Smarandache (Smarandache, 1998) presented neutrosophic components as follows:

supT = t_sup, infT = t_inf,
supI = i_sup, infI = i_inf,
supF = f_sup, infF = f_inf, and
n_sup = t_sup + i_sup + f_sup,
n_inf = t_inf + i_inf + f_inf.

The sets T, I, F are not necessarily intervals; but may be any real sub- unitary subsets, discrete or continuous; single element, finite or (countable or uncountable) infinite; union or intersection of various subsets, etc.

## 3. Neutrosophic Love model

In this section, we present a neutrosophic love model, which is linear. The classical version was studied earlier by Strogatz (Strogatz, 1994). Generally, we classify by

a) Linear love model, and
b) Non-linear love model.

Here, we confine our discussion to linear model only.

**3. A. Necessity of Neutrosophy in Love dynamics**

It is well known that, in society, there is no single factor that affects 'love affairs'. There are so many other external factors (families, relatives, friends, enemies, situations etc.) including indeterminacy that can affect the love affairs, which are not described in previous studies (Bartholomew & Horowitz, 199; Carnelly & Janoff-Bulman, 1991; Gottman, Murray, Swanson, Tyson, & Swanson, 2002, Gragnani, Rinaldi, Feichtinger, 1997; Gragnani, Rinaldi, & Feichtinger, 1997; Griffin & Bartholomew, 1994; Kobak &Hazan, 1991; Radzicki, 1993; Rinaldi,1998a; Rinaldi,1998b; Rinaldi & Gragnani, 1998; Scharfe & Bartholomew, 1994; Sternberg, 1986; Stenberg & Barnes, 1988; Strogatz, 1988; Strogatz, 1994; Wauer, Schwarzer, Cai,&Lin,2007*)*. For an example, let us suppose that a boy, Dushmanta, is forced to love an unknown girl, Sakuntala. It should be noted that the persons (who forced Dushmanta) prisoned his sister, so that the boy acts with the girl, as a lover, only for his sister. In this case, the boy neither loves nor hates the girl. We can conclude that there is some indeterminacy in love dynamics. There are so many examples like this. Therefore, we apply neutrosophic logic to Romeo-Juliet model (Sprott, 2004).

**3. B. Neutrosophic Linear love model (NLL model)**

Let's consider a love affair between Romeo and Juliet, where

R(t) = Romeo's love (or hate, if –ve) for Juliet at a particular time 't'
J(t) = Juliet's love (or hate, if –ve) for Romeo at a particular time 't'.

The simplest neutrosophic linear love model is

$$\frac{dR}{dt} = (a + bI)R + (c + dI)J$$
$$\frac{dJ}{dt} = (e + fI)R + (g + hI)J \qquad \text{(i)}$$

Simplifying, we have

$$\frac{dR}{dt} = (aR + cJ) + (bR + dJ)I$$
$$\frac{dJ}{dt} = (eR + gJ) + (fR + hJ)I \qquad \text{(ii)}$$

where I→ level of indeterminacy, and a, b, c, d, e, f ∈ R.

**3. B. i. Features of NLL model**

The parameters 'a', 'b', 'c', 'd' in NLL model specify Romeo's situational styles, and the parameters 'e', 'f', 'g', 'h', specify Juliet's situational feelings. Overall, we can say that the parameter 'a' describes the extent to which Romeo is encouraged by his own feelings, and 'c' is the extent to which Romeo is encouraged by Juliet's feelings, 'b' describes the extent to which Romeo is encouraged or discouraged by his family or other sources, and 'd' is the extent to which Romeo is encouraged or discouraged by Juliet's family.

Now, we are going to present the characteristics of this NLL model.

**3. B. ii. Characteristics of NLL model**

We may describe the situational behavior of Romeo in this NLL model by portioning our universe of discourse $U_N$ into two parts. These are:

a) Independent indeterminacy model ($U_N^{I=0}$),

b) Dependent indeterminacy model ($U_N^{I\neq 0}$).

**3. B. ii. a. Independent Indeterminacy model ($U_N^{I=0}$)**

Here, Romeo can exhibit one of the nine romantic styles, depending upon the signs of 'a' and 'c'.

1. **Eager Behavior: [if a > 0, c > 0**] i.e. Romeo is encouraged by his own feelings as well as Juliet's.
2. **Narcissistic nerd: [if a > 0 and c < 0**] i.e. Romeo wants more of what he feels; but retreats from Juliet's feelings.
3. **Secure lover: [if a < 0, b > 0]** i.e. Romeo retreats from his own feelings; but is encouraged by Juliet's.
4. **Hermit: [if a < 0 and b < 0**] i.e. Romeo retreats from his own feelings as well as Juliet's.
5. **X-inertia: [if a > 0, b = 0**] i.e. Romeo is encouraged by his own feelings; but doesn't get any reply from Juliet's.
6. **Y-inertia: [if a = 0 and b > 0**] i.e. Romeo is encouraged by Juliet's feelings; but act as a neutral person.

7. **Juliet's Hate: [if a < 0 and b = 0]** i.e. Romeo retreats from his own feelings; but doesn't get any (positive) reply from Juliet, which ultimately leads to Juliet's hate.
8. **Romeo's hate: [if a = 0, b < 0**] i.e. Romeo retreats from Juliet's feelings, but doesn't give any positive reply, which ultimately leads to his hate towards Juliet.
9. **Not love at all: [if a = 0 and b = 0]** i.e. Both Romeo and Juliet has no reaction w.r.t each other.

**3. B. ii. b. Dependent Indeterminacy model**

In this case, there is a positive value of indeterminacy in which there exists an external factor, by means of which the love of Romeo and Juliet is affected.

1. **Limit touches the sky: [if a, b, c, d>0**] i.e. Romeo and Juliet encouraged by themselves as well as their families.
2. **Up-Romeo: [if a > 0, c > 0, b > 0, d < 0]** i.e. Romeo encouraged by himself, Juliet and his family; but the family of Juliet doesn't accept this proposal.
3. **Up-Juliet: [if a > 0, c > 0, b < 0, d>0**] i.e. Romeo & Juliet are encouraged by themselves; but Romeo's family doesn't cooperate for this love affairs.
4. **Unsecured love: [if a > 0, c > 0, b < 0, d<0]** i.e. Both Romeo and Juliet are encouraged by their love; but neither Romeo's family nor Juliet's family agree for this affair.
5. **Forced Juliet: [if a > 0, c < 0, b > 0, d>0**] i.e. both the families of Romeo and Juliet are correlated and agreed in this love affair. And Romeo is encouraged by his own love affair; but retreats from Juliet's feelings i.e. Juliet is forced to love or suppress her love.
6. **Failed Romeo: [if a > 0, c < 0, b > 0, d<0**] i.e. Romeo is encouraged by himself as well as his family; but retreats from Juliet's feelings and her family.
7. **Harassed Romeo: [if a > 0, c < 0, b < 0, d<0]** i.e. Romeo is encouraged by himself only; but has no support from both Juliet and their families.
8. **Crossed Love: [if a>0, c<0, b<0, d>0]** i.e. Romeo is encouraged by himself. Romeo's family agrees with the affair; but neither Juliet nor her family accept this affair.
9. **Suspected Love: [if a < 0, c > 0, b > 0, d>0**] i.e. Romeo retreats from his behavior and encouraged from both Juliet's behavior and her family. In this case, either Romeo suppresses his love or loves any other girl.
10. **Crossed Love [if a < 0, c > 0, b >0, d<0]** i.e. when Romeo isn't agreed, his family is agreed; but it is opposite for Juliet.
11. **Fickle Love: [if a < 0, c > 0, b < 0, d<0]** i.e. Romeo retreats from his own behavior as well as families, but encouraged by Juliet.
12. **One sided: [if a < 0, c > 0, b < 0, d > 0]** i.e. Romeo & his family retreats from the behavior of Juliet as well as her family.
13. **Family love: [if a < 0, c < 0, b >0, d > 0**] i.e. Romeo & Juliet aren't encouraged by themselves. Only their families are agreed.
14. **Not love: [if a < 0, c <0, b < 0, d < 0]** i.e. No factors are interested in this affairs.
15. **Fluctuated R-family: [if a < 0, c < 0, b > 0, d < 0]** i.e. Only Romeo's family is interested in this affairs.
16. **Fluctuated J-family: [if a < 0, c < 0, b < 0, d > 0]** i.e. Only Juliet's family is interested in this affair.

17. **Neutral Juliet: [if a > 0, c = 0, b > 0, d > 0**] i.e. Juliet is neutral in this affairs.
18. **Single Romeo: [if a > 0, c = 0, b < 0, d < 0]** i.e. only Romeo encouraged from his behavior.
19. **Lonely Romeo: [if a > 0, c = 0, b < 0, d < 0]** i.e. only Romeo is encouraged by his behavior; neither Juliet, nor their families.
20. **Moderate Romeo: [if a >0, c = 0, b< 0, d> 0]** i.e. the love is moderate, that is only Romeo is encouraged by his behavior.
21. **Neutral Romeo: [if a = 0, c > 0, b > 0, d > 0**] i.e. Juliet and her family are encouraged by themselves.
22. **Single Juliet: [if a = 0, c > 0, b < 0, d < 0]** i.e. only Juliet is agreed and Romeo is encouraged by Juliet's feelings.
23. **Moderate Juliet: [if a = 0, c > 0, b > 0, d < 0]** i.e. only Romeo is encouraged by the feelings of Juliet.
24. **Moderate J-family: [if a = 0, c > 0, b < 0, d > 0**] i.e. only Juliet is agreed in this proposal.
25. **Unarranged J-love: [if a < 0, c = 0, b > 0,d >0]** i.e. only families of the lovers are agreed in this proposal.
26. **No love: [if a < 0, c < 0, b < 0, d <0**] i.e. there exists no love.
27. **Failed J-love: [if a < 0, c = 0, b <0, d > 0**] i.e. only Juliet's family show their interest; but there is no interest from Romeo and Juliet.
28. **Failed R-Love: [if a < 0, c = 0, b > 0, d < 0]** i.e. only Romeo's family show their interest in this proposal.
29. **Unarranged R-love: [if a = 0, c < 0, b > 0, d > 0]** i.e. Families of the lovers are agreed in this issue.
30. **Family J-love: [if a = 0, c < 0, b < 0, d > 0]** i.e. only the family of Juliet agrees.
31. **Family R-love: [if a = 0, c < 0, b > 0, d <0]** i.e. only the family of Romeo agrees.
32. **No love: [if a=0, c<0, b<0, d<0]** i.e. none factors agreed and Juliet kept her behavior as neutral.
33. **One sided R-family: [if a = 0, c = 0, b > 0, d < 0**] i.e. only the family of Romeo is agreed in this proposal.
34. **One sided J-family: [if a = 0, c = 0, b < 0, d > 0]** i.e. the family of Juliet is agreed and there is no interest of others.
35. **Neutral lovers: [if a = 0, c = 0, b > 0, d > 0]** i.e. the lovers are kept as neutral and their families are interested in this issue.
36. **Never love: [if a = 0, c = 0, b < 0, d < 0]** i.e. all factors show the uninterested intention for this issue.

**3. C. Impact factor of Love Definition:** Let $U_N$ be the universe of discourse. Let 'LIF' be the impact factor of a love affair, which is defined as the index of affection of the love affair, whether it is going to succeed or to fail, or in between them.

The love impact factor is denoted as 'LIF' and defined as follows:

$$LIF = \delta_{N_{TL}, N_{IFL}} \begin{cases} < 0: \text{if } N_{TL}, N_{IFL} < 0 \\ \quad 1. \qquad = 0: \text{if } N_{TL}, N_{IFL} = 0 \\ = 1: \text{if } N_{TL}, N_{IFL} \leq \ \geq 0 \\ > 1: \text{if } N_{TL}, N_{IFL} > 1 \\ \geq 1: \text{if } N_{TL}, N_{IFL} \geq 1 \\ \leq 0: \text{if } N_{TL}, N_{IFL} \leq 0 \end{cases}$$

where, $N_{TL}$ & $N_{IFL}$ are the love functions of the parameters (a, c) and (b, d) respectively, and it is defined as follows:

$$N_{TL} = f_N(a, c) = \begin{cases} < 0 : \text{if a, c} < 0 \\ = 0 : \text{if a , c} = 0 \\ = 1 : \text{if a or c=0} \\ > 1 : \text{if a} > 0, \text{c} > 0 \\ \geq 1 : \text{if a} \geq 1 \text{ and c} \geq 1 \\ \leq 0 : \text{if a, c} \leq 0 \end{cases}$$

and

$$N_{IFL} = f_N(b, d) = \begin{cases} = 1 : \text{if b or d} = 0 \\ > 1 : \text{if b} > 0, \text{d} > 0 \\ \geq 1 : \text{if b} \geq 1 \text{ and d} \geq 0 \\ \leq 0 : \text{if b, d} \leq 0 \\ = 0 : \text{if b , d} = 0 \\ < 0 : \text{if b} < 0, \text{d} < 0 \end{cases}$$

Now we consider some cases as follows:

**Examples: (Regarding LIF)**

1. Let's consider the case of 'limit touches the sky'. In this case, a >0, b > 0, c >0, d > 0 . So $N_{TL} > 1$ and, $N_{IFL} > 1$ this implies LIF > 1, which implies that it is very much effective love.
2. Let's consider the case of 'Up-Romeo'. In this case, $N_{TL} > 1, N_{IFL} = 1$, this implies 1- $\in \leq$ LIF $\leq 1$, for all very small positive $\in$. It is like a fluctuating love, leading to success.
3. Let's consider the case of 'unsecured love'; in this case,

2. $$N_{TL} = 1 \ \& \ N_{IFL} > 1$$
$$\Rightarrow 1 - \in \ \leq \ \text{LIF} \leq 1, \forall \in > 0$$

So it is a case of fluctuating love, leading to success.

Like this, we can study any case described in Section 3, case, and can find the 'love index factor' for accuracy.

For inquiring minds, we suggest some research level open problems, as following.

## 4. Open problems

1. Extend the love dynamics to neutrosophic love triangles.
2. Propose new neutrosophic love models based upon ancient / modern society.
3. Create a neutrosophic model on attachment process.
4. Propose a neutrosophic love model and analyze it for a secure individual, etc.

## 5. Conclusions

The aim of this paper was to present a new neutrosophic love model, which would be able to describe the whole love features. Also, we proposed here for the first time the love impact factor (LIF). Due to insufficiencies of previous works, we decided to apply the neutrosophy to love dynamics, since 'love' involves indeterminacy. 'Love dynamics' being a very interesting and open topic for research, the present study may open up new avenue of research for current neutrosophic research arena.

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